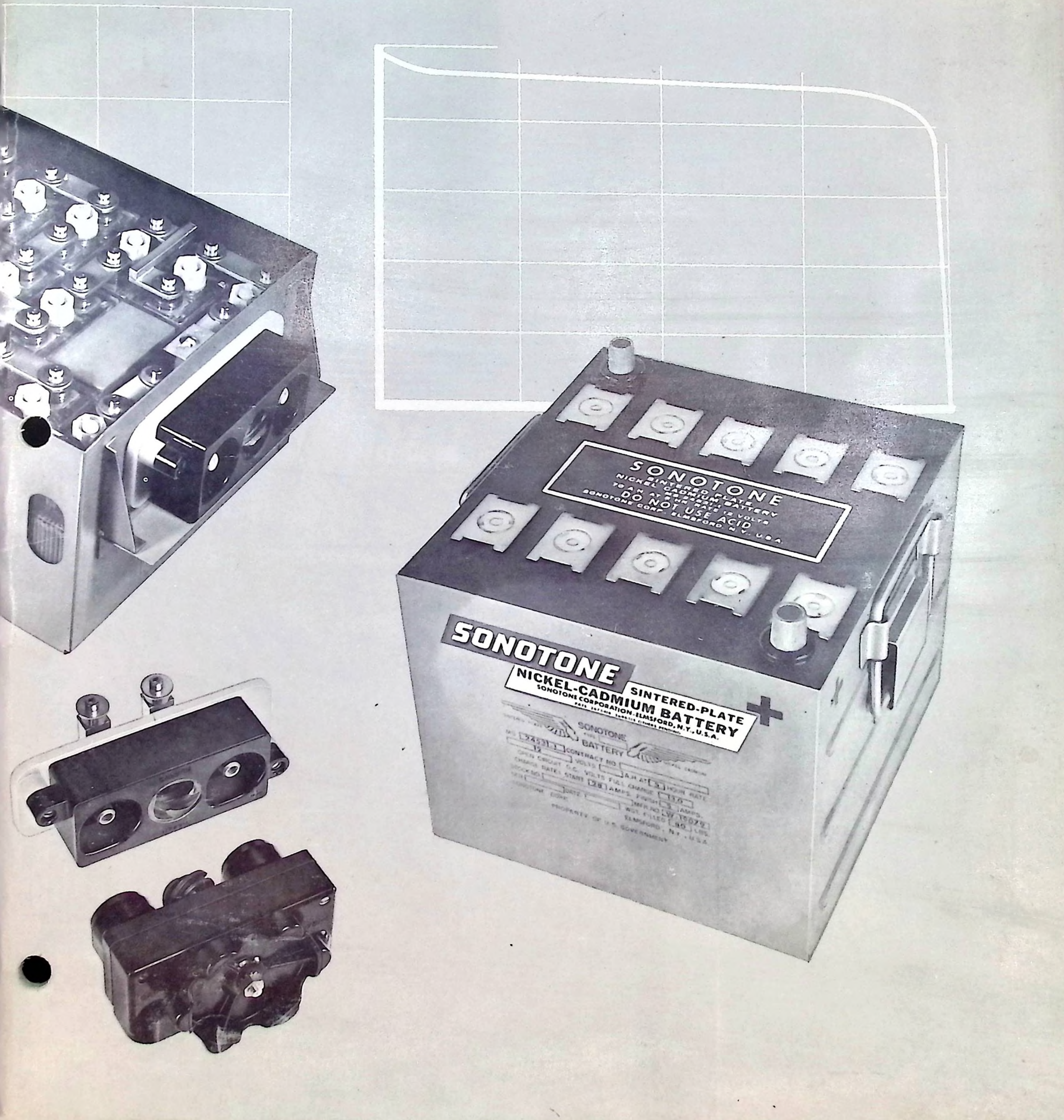
1968 EDITION

SONOTONE BATTERY INSTRUCTION MANUAL

SINTERED-PLATE, NICKEL-CADMIUM BATTERIES



INSTRUCTION MANUAL

SONO-CAD*

SINTERED-PLATE, NICKEL-CADMIUM BATTERIES

BY SONOTONE®

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INTRODUCTION

This manual has been prepared to acquaint you with the fundamental operating characteristics of SONOTONE® sintered-plate, nickel-cadmium batteries and to assist you in obtaining maximum performance with minimum maintenance and servicing.

Over a period of years, literally thousands of SONO-CAD™ battery units have been operating in aircraft, missiles, satellites, ground vehicles, communication equipment, marine installations, ground power standby equipment and hundreds of other applications where rechargeability, flexible voltage and reliable power are essential.

Your Sonotone battery is manufactured to the highest precision standards. Care has been taken in every step of the manufacture to assure a product of the very highest quality. Your battery has been carefully tested at factory laboratories before being shipped. Proper care and maintenance, as outlined in this manual, will aid you in keeping your battery at peak performance and prolong its useful life.

PART I–PRINCIPLES OF OPERATION

1.0 Electro-Chemical Principles of the Sonotone Battery

1.1 DURING CHARGE

The active material of the negative plate is cadmium-oxide. When the charging current is applied, this material gradually loses its oxygen and becomes metallic cadmium. The active material of the positive plate is nickel-oxide. This is brought to a higher state of oxidation by the charging current. As long as this current continues, changes take place until both materials are completely converted.

Toward the end of this charging process, and during overcharge, Sonotone cells will gas. This is a result of electrolysis of the water component of the electrolyte. The gas created at the negative plates is hydrogen and that at the positive plates is oxygen. The amount of gas created is dependent upon the temperature and the amount of charging current.

The cells will accept charge at temperatures ranging from —65° to +165°F. The electrolyte does not enter into any chemical reaction with either the negative or positive plates, but acts merely as a conductor of current between them. There is no significant change in the specific gravity, since the electrolyte acts only as a conductor.

1.2 DURING DISCHARGE

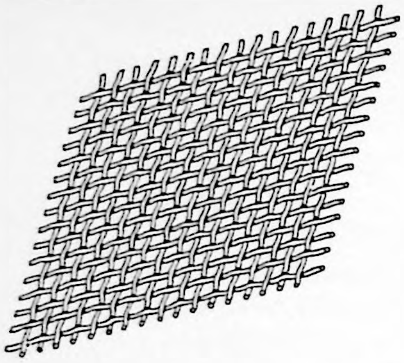
A chemical action in reverse of that which occurs during charge is immediately initiated when electrical energy is withdrawn from the cell. The negative plate gradually gains back oxygen and the positive plate gradually loses oxygen. There is no gassing on normal discharge due to this interchange of oxygen.

This process results in the conversion of the chemical energy of the plates into electrical energy. The rate of which this conversion takes place is primarily determined by the external resistance imposed by the electrical circuit to which the cell is connected. Due to the type of cell construction, there is extremely low internal resistance within the cell. The chemical nature of the electrolyte and its specific gravity remain unchanged during discharge. The relative constancy of the cell voltage during discharge is due mainly to these factors.

2.0 *Construction of the Sonotone Battery*

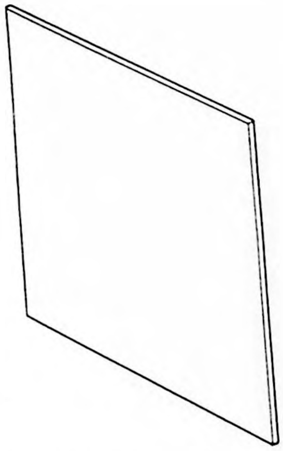
2.1 PLAQUES AND PLATES

The basic feature of the Sonotone battery is its sintered plate, as shown in the series of diagrams below.

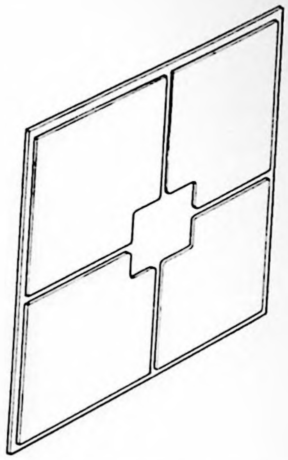


1. Here's how a Sonotone battery is made. We start with a nickel screen.

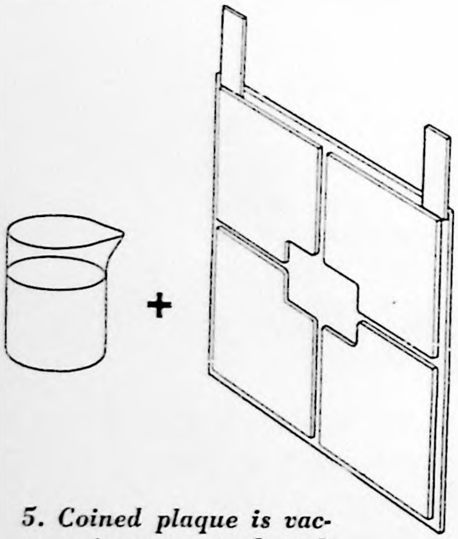
2. Then nickel powder is sintered about screen.



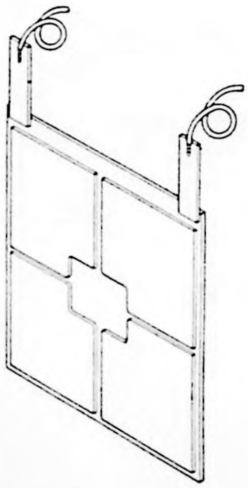
3. This forms a plaque approximately 80% porous at this stage.



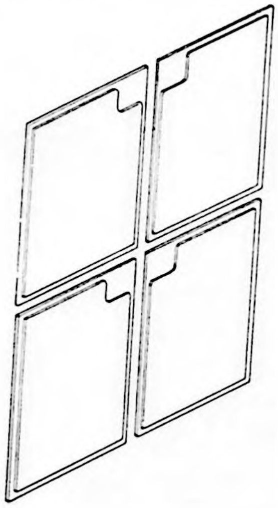
4. Plaque is coined with a plate die.



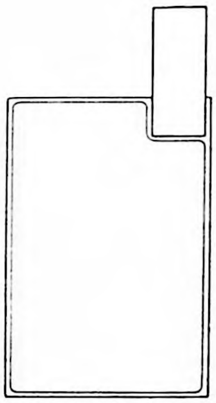
5. Coined plaque is vacuum impregnated with nickel or cadmium salts, electrochemically deposited within pores.



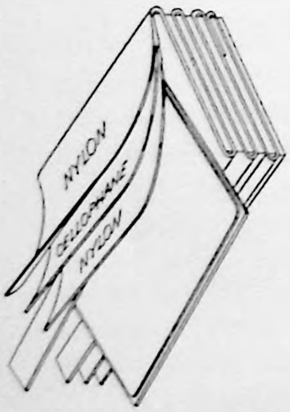
6. Current is passed through plaque in presence of electrolyte, to convert nickel or cadmium salts to final form.



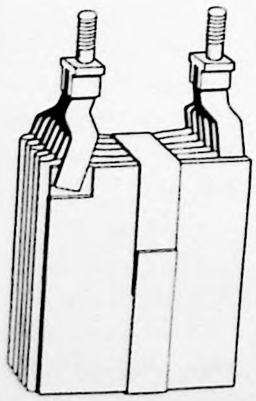
7. After washing and drying, finished plaque is cut into plates.



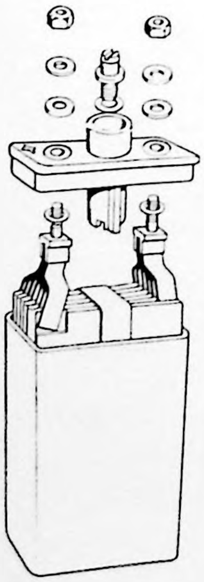
8. A nickel tab is spot welded to plate.



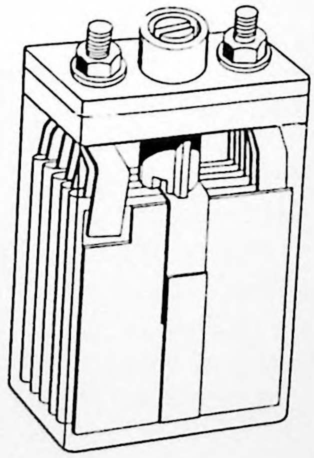
9. "Stackup" is prepared by folding separator material between alternate positive and negative plates.



10. Nickel terminals are welded to completed "stackup," which with its cellophane binder forms the complete assembly of the core.



11. Cover and vent assemblies are attached and sealed to "stackup."



12. Entire unit is inserted in cell case and sealed.

2.2 SINTERED-PLATE CONSTRUCTION METHODS

Sintering is that process by which micro-fine powder is fused together at high temperatures to form a porous plaque structure. The porous structure of the Sonotone plaque is obtained by sintering nickel powder to a fine-mesh wire screen. The active material which distinguishes between the negative and positive plates is then electrochemically deposited within the pores of the plaque. Positive plaques are made by depositing nickel-hydroxide, negative plaques by depositing cadmium-hydroxide.

The plaques are then formed, washed, dried and cut into the desired plate size. Nickel connecting tabs are welded to one corner of each plate. Positive and negative plates are then grouped into a core assembly. The connecting tabs of all plates project upward toward the proper terminals, to which they are welded.

The sintered plates are positioned very closely together and are kept from actual physical contact by a thin multi-layer laminate, known as a separator.

While the surface of a sintered plate appears to be relatively smooth, it is actually a maze of tiny hills and valleys *(see Figure 1)*. This physical property multiplies the apparent surface area several hundred times and permits the utilization of a tremendous area of active material. The porosity of the plate permits the absorption of electrolyte. This further increases the volume of active material in direct contact with the electrolyte.

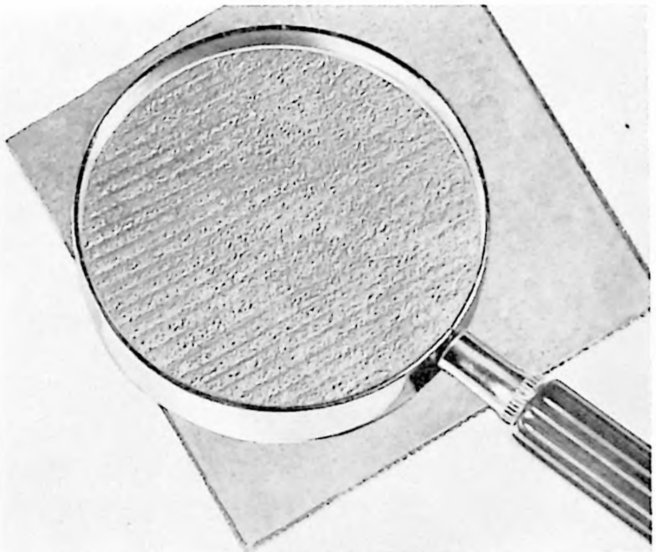


FIGURE 1

The porosity of Sonotone plates is created by a partial sintering of the nickel powder. This powder has been carefully selected for particle size and shape. After sintering, the total active surface area of one Sonotone nickel-cadmium plate is equal to that of several hundred solid plates of the same size.

2.3 SEPARATORS

A continuous strip of highly specialized fabric and pliable plastic composes the separator. This continuous separator is interposed between the plates as each successive plate is added to the "stackup" in preparing the core assembly. Thus the plates within the core are separated by a porous insulating barrier. This design provides the needed physical strength with minimum bulk and excellent electrical insulation, as well as efficient electrolytic conduction when immersed in the electrolyte. To insure complete insulation, the separator is slightly wider than the dimensions of the plate.

2.4 CELLS

The core assembly in a Sonotone battery is firmly affixed to a plastic or metal cover. This integral unit is then fitted snugly within a transparent plastic or metal case and the cover is cemented or welded in position. The cell thus becomes a compact, enclosed unit. The plates extend to the bottom of the cell, since no active material will flake or shed from them. This contributes to the solidity of the cell and gives it the ability to withstand extreme conditions of shock and vibration.

2.5 VENTS

Each cell is provided with a vent plug. This plug consists of a metal or plastic core and an outer collar of rubber. It can be removed for the addition of distilled water or adjustment of the electrolyte. When in place, the rubber expansion collar permits the gas created on charge to escape. Since there is no gassing on discharge, the vent automatically seals the cell, preventing leakage of electrolyte and also preventing entrance of foreign substances into the cell.

2.6 BATTERY ASSEMBLIES

To provide the voltage for a given application, cells are assembled into batteries and are housed in a steel battery case. An individual cell may be replaced in the event of damage, thus eliminating loss of the entire battery.

2.7 ELECTROLYTE

A 30%-by-weight solution of potassium hydroxide (KOH) in distilled or demineralized water is used as the electrolyte in the Sonotone battery.

No overall chemical change occurs in the electrolyte during charge or discharge. As a result, no appreciable changes in the specific gravity are observed. The specific gravity of the electrolyte at room temperature remains between 1.24 and 1.32. The electrolyte level, observed through the windows in the side walls of the battery case or by looking into the vent wells, should be at the top of the plate portion of the core assembly. Sonotone batteries are normally shipped wet from the factory, since shelf life is not affected.

3.0 Discharge Characteristics of Three Basic Sonotone Battery Types

3.1 PLATE THICKNESSES

Sonotone batteries of the sintered-plate, nickel-cadmium type are divided into three classes, in accordance with the following discharge requirements:

a. H-TYPE BATTERIES—Contain thin plates and are intended for very high current service such as required in turbine engine-starting applications, particularly during cold-temperature operation.

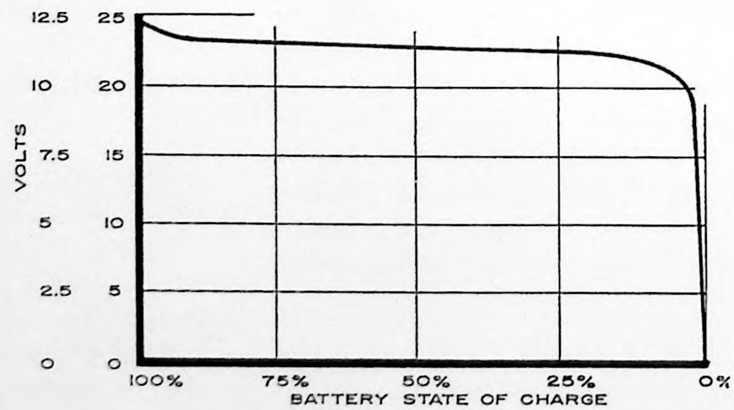
b. M-TYPE BATTERIES—Contain medium thick plates and are intended for medium rate current requirements, such as reciprocating engine starting applications. They will perform satisfactorily at all temperature ranges—from sub-zero Antarctic conditions to the blistering tropics.

c. L-TYPE BATTERIES—Contain thick plates and are intended for low current drains where great capacity at a low rate is required, such as transistorized power supplies. They will perform satisfactorily at low temperatures at very low current drains.

3.2 TYPICAL DISCHARGE CHARACTERISTICS

All Sonotone batteries offer a constant voltage throughout their discharge. Figure 2 illustrates a typical discharge voltage curve under moderate load.

FIGURE 2



TYPICAL DISCHARGE VOLTAGE CURVE UNDER MODERATE LOAD

PART II–INSTALLATION

4.0 *Unpacking and Inspection of New Batteries and Cells*

4.1 INSPECTION PRIOR TO INSTALLATION

When the battery is unpacked, a thorough inspection should be made to insure that no damage occurred during shipment. Inspect the shipping container, as well as the battery, to make certain that the cells have not been damaged. Before putting your battery in service, follow these points carefully:

4.2 CHECK LIST

a. *CHECK FOR DAMAGE*—See if any liquid has spilled into the shipping container. This may be a sign of a damaged cell.

b. *CHECK ELECTRICAL CONNECTION*—Check all electrical connections for tightness. Test all screws and nuts on all terminals to insure tightness. Poor electrical contact may result in damage to your battery.

c. *CHECK LIQUID LEVEL*—CAUTION: Sonotone batteries are shipped with the proper amount of liquid. Do not add liquid until you have first attempted to charge your battery. When a battery has been discharged or allowed to stand unused for a long period of time, the electrolyte becomes absorbed into the plates. Your battery has been shipped discharged, which is the chief reason why the liquid level is low. Charging the battery will cause the liquid level to rise to a point just above the tops of the plates.

d. *CHECK VENTS*—Your battery is equipped with special type vents which permit the gases to escape from the cells. Do not obstruct these vents in any manner which will interfere with their operation. Some batteries are shipped with solid vent plugs which are used as shipping plugs. If these have been used on your battery, the battery will be marked with a tag, "Remove Shipping Plugs." The vent plugs are then inside a small cloth bag tied to the battery. Replace shipping plugs with the vent plugs before charging the battery.

e. *INDIVIDUAL CELLS*—When individual cells have been ordered, care must be exercised in charging. Do not charge individual cells unless the plastic cell case is supported externally in some manner. Gas pressure during charge on unprotected cells may crack the cell case. If no clamping device is available, remove the filler caps or vent screws to prevent a buildup of gas pressure inside the cell during charge *(consult Operation and Maintenance, 5.0).*

4.3 INSTALLATION OF THE BATTERY

4.3.1 CLEANING COMPARTMENTS

Prior to installation, compartments or battery boxes which have previously housed lead-acid batteries must be washed out, neutralized with ammonia or washing soda solution, allowed to dry thoroughly and then painted with alkaline-resistant paint.

4.3.2 CHARGING NEW BATTERY

Your battery has been discharged prior to shipment. It will therefore need charging before installation *(see Table I).* If by special order your battery is shipped in a charged state, it is advisable to give it a freshening charge *(consult Charging Methods, 5.3).*

4.3.3 SECURING BATTERY IN POSITION

When installing the battery in its permanent location, care should be taken to see that all post nuts are drawn down tight and that all electrical connections are made secure. Leads to the battery should be of sufficient size to carry the maximum current encountered without excessive voltage drop. If the battery is in mobile service, such as on an aircraft or other vehicle, it must be secured by holddowns. It is desirable to arrange the compartment so that the battery is either accessible or can be readily removed for servicing.

4.3.4 PROPER AIR CIRCULATION

Stationary batteries consisting of several tray groups should be installed with trays separated from each other to permit some circulation of air. This air space around the trays also serves to break up possible current leakage paths. Tray-to-tray connectors are of proper length to allow a minimum of ⅛″ between trays.

4.3.5 VENTING OF GASES

Where the batteries are installed in a confined location, it must be realized that some hydrogen and oxygen gases are evolved during the charging cycle. It is therefore necessary to provide some means of ventilation to remove these gases from this confined area, avoiding accidental ignition of the hydrogen.

There are two types of venting systems to be considered. The first is a battery case containing vent nozzles and the second the battery case containing viewports or cover containing louvers. If the battery case contains vent nozzles, these must be used to vent gases either overboard or into a compartment that will meet the air flow requirements outlined below. If the battery case contains viewports or cover has louvers, the air flow must be of sufficient volume to keep the mixture of air and hydrogen below 5%. In both cases mentioned above, the air flow should be a minimum of 5 cubic feet per minute.

4.3.6 CHECKING POLARITY

Check the polarity of each cell or group of cells to be sure that they are connected in proper series. The polarity of each cell is indicated by a plus sign molded into the cell cover adjacent to the appropriate cell post.

4.3.7 INSULATING BATTERY

Sonotone has recently developed a new epoxy coating for its line of aircraft batteries. This epoxy coating is designed to improve the insulation between the cells and the battery container. It will eliminate the small discharge current formerly produced when spillage or spewage of electrolyte was encountered. This is a standard item on certain batteries produced at this time and will be a standard item on most units produced in the future.

Batteries in the field that are not now epoxy coated may have this done by returning the battery to Customer Return Department, Battery Division, Sonotone Corporation, Cold Spring, N. Y. 10516. The cost is determined by the battery type. Where batteries are mounted in groups, it may be necessary to provide insulation from each other and from the trays in which they are mounted *(consult Trouble Shooting, 7.0)*.

4.3.8 VOLTAGE REGULATION

Where the battery is being used in a mobile application, such as aircraft or ground vehicles, it will be necessary to make certain that the voltage regulating device is set to the proper limits, *as indicated in Table I*. This is an extremely important phase of your installation, as an improper voltage regulator setting can destroy a Sonotone sintered-plate, nickel-cadmium battery in a relatively short period of operation.

4.3.9 QUICK DISCONNECT DEVICES

Should the battery be installed using a multipin quick-disconnect type of plug, it is important to be certain that the connecting half of the plug, which is normally attached to the vehicle or aircraft, is wired correctly with respect to the terminal pins on the battery. A battery installed in an electrical circuit with the polarity reversed will not perform and may become seriously damaged.

4.3.10 SAFETY WIRING

In installations where safety wiring is to be used, be extremely cautious about the use of this wire near or on battery and cell terminals. It is in some instances, possible to completely isolate the metal battery case from the electrical system into which it has been installed and then establish a direct short to ground through the improper use of safety wire.

When installation is completed, be sure that no loose objects, such as screws or tools, have been accidentally left in the battery compartment or inside the battery.

PART III–
OPERATION, MAINTENANCE AND TROUBLE SHOOTING

5.0 Operation and Maintenance

5.1 GENERAL CARE

To obtain continued peak performance, a Sonotone battery should be kept in a clean, dry state. Batteries that are subjected to deposits of metallic dust on the cells, such as those in locomotive or steel plant stations, should be covered. The buildup of metallic dust or any other conductive substance will self-discharge the cells more rapidly by providing a conductive path.

Keep open flame and metal objects, such as tools, etc., away from the exposed parts of the battery. If objects are accidentally dropped across the terminals, these might cause a short circuit that could damage a cell or cells.

Should the batteries accumulate dust or a white deposit which sometimes forms around the tops of the cells, it is advisable to flush the tops of the batteries with ordinary tap water.

CAUTION: Do not attempt to clean the battery tops with solvents, acids or any chemical solution. Sonotone batteries are primarily constructed with plastic or nylon cells. The plastic may be injured by introducing solvents, etc. While flushing the batteries with tap water—if necessary—it is permissible to use a bristle brush to clean any stubborn dirt particles.

CAUTION: Do not use wire brushes. After cleaning, any excess liquid should be drained and the batteries should be permitted to dry. Where possible, this drying may be accelerated by the use of compressed air.

5.2 CHARGING CHARACTERISTICS

A Sonotone nickel-cadmium battery will accept a charge at a much faster rate than a lead acid battery and may be charged at temperatures below −20°F. Charging is more efficient at battery temperatures between +40° and +80°F.

5.3 CHARGING METHODS

As mentioned earlier in the section entitled *Installation,* it will be necessary to charge your battery prior to putting it into service. While in service in many installations, the battery will be charged by the equipment in which it is installed. During particular maintenance and inspection removals, however, it may be necessary to charge the battery in the shop. *IMPORTANT— BATTERIES MUST BE CHARGED IN AN UPRIGHT POSITION.* The construction of the Sonotone sintered-plate cell is such that it is readily adaptable to standard charging systems. These include constant voltage, constant current, stepped constant current charge or float charging. Most efficient performance from a constant current will result when the charging rate is such that 140% of the rated capacity of the cell is returned at the rates *indicated in Table I.*

The following material is devoted to various charging methods:

5.3.1 CONSTANT CURRENT CHARGING

The length of time required to charge a battery by the constant current method depends on the size or capacity of the battery, the state of charge of the battery and the magnitude of the charge current. In order to maintain a constant current, it should be noted that the voltage of the system will run from 1.4 volts per cell at the beginning of charge to a maximum of 1.75 volts per cell at the end of charge. In *Table I,* we recommend a constant current rate which is arrived at in the following manner: Take the current output at the 5-hour rate and charge at that current for 7 hours. *Example—the recommended constant current charge for a 40-ampere-hour battery would be computed as follows: 40 ampere hours divided by 5 hours equals 8 amperes.* You would therefore charge this battery at 8 amperes for 7 hours. A typical constant current charging curve *is shown in Figure 3.*

Constant current charging can be accomplished manually by monitoring the charging apparatus and adjusting the voltage periodically to maintain a constant charge rate. Chargers of the self-regulating rectifier type are available to provide constant current without the attention of an operator. Sonotone Corporation manufactures a Battery Charger/Ana-

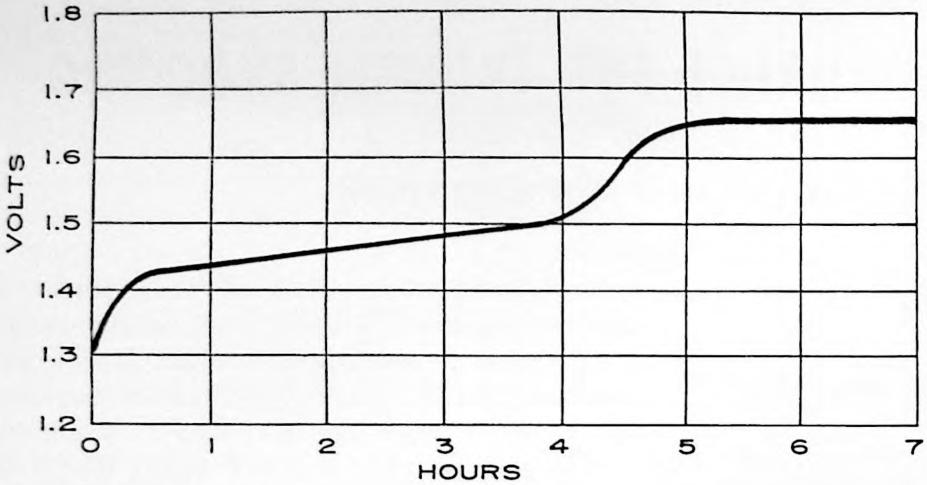


FIGURE 3

TYPICAL VOLTAGE VARIATION DURING CONSTANT CURRENT CHARGE

lyzer designed for this purpose. A complete brochure may be obtained from the Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523. *Request Data Sheet BA-166.*

If a battery is partially discharged, the charge rate *shown in Table I* will still apply. It may not be necessary, however, to charge the battery for the full length of time indicated. To determine whether the battery has reached the full charge state, monitor the battery and note the time that the voltage takes the sharp rise *indicated in Figure 3.* After the sharp voltage rise, it is then necessary to permit the battery to charge for an additional 2 hours at the rate *shown in Table I.* During this 2-hour portion of charge, it is possible to check the cell voltages and determine whether all cells are rising evenly. Should some cells indicate a voltage lower than 1.55 volts, it is advisable to leave the battery on charge until these cells come up to a minimum of 1.55 volts.

Note: During the greater portion of charge, the cell voltages will remain between 1.4 and 1.45 volts. On a conditioned battery, when it has been charged for approximately 70% of the time necessary to charge it fully, the voltage will take the sharp rise mentioned above. Should the individual cell voltage fail to rise to 1.55 volts or more, it may be necessary to replace these cells *(consult Trouble Shooting, 7.0).*

5.3.2 STEPPED CONSTANT CURRENT CHARGING

If it is necessary to obtain a rapid charge, the principles of the previous paragraph still apply—the battery may be permitted to charge at a current equal to its capacity. *Example—a 40-ampere-hour battery at a charging rate of 40 amperes.* At this high rate, the battery should be monitored and when the total battery voltage averages 1.50 volts per cell, the rate should then be reduced to the rate shown on Table I. At the time of reduction, a conditioned battery will have completed approximately 70% of the charge cycle if it was completely discharged to begin with. This method of charging must be monitored, as the high rate will eventually use all the water in the battery if permitted to continue past the gassing point. This loss of water will cause higher concentration of the electrolyte and possible overheating which will damage the cell.

5.3.3 FLOAT CHARGING

Fully charged batteries may be floated across a line voltage of approximately 1.42 volts per cell. Example—a 24-volt aircraft battery which contains 19 cells may be trickle charged at 27.0 volts. A battery floated in this manner will draw about .003 amperes per ampere hour of capacity. *Example—a 40-ampere-hour battery will float at approximately .120 amperes.* This voltage setting will vary slightly with ambient temperature of operation.

5.3.4 CONSTANT VOLTAGE CHARGING

In most applications where Sonotone sintered-plate, nickel-cadmium batteries are used, the constant voltage charging method is employed. Aircraft, automobiles, boats, factory equipment and all mobile applications use the voltage-regulated genera-

NOTE: Additional constant current charging instructions when using Sonotone Battery BB-449/U at low temperatures—current of 2.8 amperes should be used for a period of 7 hours. Although this method may be used at temperatures below −20°F, it is usually not recommended.

tor charging circuit. The graph *shown in Figure 4 (Page 22)* indicates what happens essentially during this type of charge.

A voltage produced by the generator permits current to flow to the battery. In a discharged battery, the maximum surge of current will be approximately 10 times the rated capacity. The high surge currents are due to the low internal resistance of the battery. Make certain that the charging source is protected against overload in the event of a marginal power supply. As the battery approaches a charged state, the current falls off rapidly and the voltage rises. The recommended voltage setting for the regulator, *shown in Table I*, is computed by multiplying the number of cells in the battery by a factor of 1.5 to 1.55. *Example—a 12-volt automotive battery which contains 10 cells should have the regulator set to cut out between 15.0 and 15.5 volts.*

It should be noted that this type of charging, particularly in applications where the battery is excessively discharged, may produce an unbalance in cell capacity *(consult Trouble Shooting—Apparent Loss of Capacity, 7.1)*. If the battery requires equalization and a constant current charging source is not available, it may be equalized by the method *shown in Reconditioning Service Procedures, 9.3.*

5.4 DISCHARGING THE BATTERY

You will note, in the section entitled *Replacement of Damaged Cells, 6.1*, that you are instructed to discharge the battery. The following information is designed to help you in this operation.

5.4.1 USING EQUIPMENT AS A LOAD

A battery may be discharged by merely permitting it to operate the equipment in which it is installed without permitting the generator or other charging source to replenish it.

When the battery fails to operate the equipment, it is in a state of partial discharge. It should then be removed from the equipment and discharged through a resistance high enough to permit the current to flow at approximately the 2-hour rate. *Example—a 40-ampere hour battery may be permitted to discharge at 20 amperes or less.* When the voltage has dropped to a sufficiently low point that the current has apparently ceased to flow, the battery can then be considered discharged. Where cells are to be individually shorted *(see Figure 5)*, it is important that the shorting wires or bars be placed in position on the cells while the resistance is still connected to the battery.

Should the battery be permitted to stand after the resistance has been removed, it will recover sufficiently so that the application of the shorting devices will create severe arcing and intense heat. To determine when a battery has been sufficiently discharged and ready for short circuit, the terminal voltage of the entire battery must be less than 10% of the rated voltage. It is then safe to short circuit. *Example—a 12-volt battery having been discharged at a rate equal to or lower than the 2-hour rate may be short circuited when the terminal voltage of the entire battery is 1.2 volts or less.* Where possible, the shorting of individual cells is suggested.

5.4.2 USING A RESISTANCE LOAD BANK

A battery being discharged in the shop may be discharged through a resistance which will permit the current to flow at a rate no higher than its 1-hour rate. Example—a 40-ampere hour battery may be discharged at a rate of 40 amperes. When the battery appears to be discharged and current is no longer flowing, it is then advisable to continue to discharge through a slightly higher resistance, permitting the current to flow at the 2-hour rate or lower. *Example*

(Continued on Page 12)

NOTE: Additional constant voltage charging instructions when using Sonotone Battery BB-449/U—this method may be used at all temperatures. The recommended voltage settings are as follows:

Temperature	*Voltage*
90 to 110°F	*29 ± 1*
50 to 90°F	*30 ± 1*
0°F	*32 ± 1*
—20°F	*33 ± 1*
—40°F	*35 ± 1*

The maximum current delivered by the charger should be 30 to 100 amperes.

Table I—Charging Data

SONOTONE VEHICULAR & GENERAL PURPOSE BATTERIES

			CAPACITY			*CHARGING*		
Sonotone Type	*Cell Type*	*Volts*	*A. H. 5-Hr. Rate*	*20-Min. Amps.*	*5-Min. Amps.*	*Constant Current Amps.*	*Constant Current Hours*	*Constant Voltage Regulator Set*
5-1H120	1H120	6	.8	2	15	.2	7	7.5- 7.75
10-1H120	1H120	12	.8	2	15	.2	7	15.0-15.5
5-2H120	2H120	6	2.0	5	20	.4	7	7.5- 7.75
10-2H120	2H120	12	2.0	5	20	.4	7	15.0-15.5
5-3L420	3L420	6	4.7	10	25	1	7	7.5- 7.75
10-3L420	3L420	12	4.7	10	25	1	7	15.0-15.5
5-3H120	3H120	6	4.0	10	30	.8	7	7.5- 7.75
10-3H120	3H120	12	4.0	10	30	.8	7	15.0-15.5
5-5L420	5L420	6	7.5	12	35	1.5	7	7.5- 7.75
10-5L420	5L420	12	7.5	12	35	1.5	7	15.0-15.5
5-5H120	5H120	6	6.5	15	50	1.2	7	7.5- 7.75
10-5H120	5H120	12	6.5	15	50	1.2	7	15.0-15.5
5-10L420	10L420	6	14	25	75	3	7	7.5- 7.75
10-10L420	10L420	12	14	25	75	3	7	15.0-15.5
5-10H120	10H120	6	13	35	120	2.5	7	7.5- 7.75
10-10H120	10H120	12	13	35	120	2.5	7	15.0-15.5
5-20H120	20H120	6	22	65	200	4.5	7	7.5- 7.75
10-20H120	20H120	12	22	65	200	4.5	7	15.0-15.5
5-20M320	20M320	6	24	60	180	5	7	7.5- 7.75
10-20M320	20M320	12	24	60	180	5	7	15.0-15.5
5-40M320	40M320	6	44	110	350	9	7	7.5- 7.75
10-40M320	40M320	12	44	110	350	9	7	15.0-15.5
5-41H120	41H120	6	41	110	350	8	7	7.5- 7.75
5-60M320	60M320	6	60	150	450	12	7	7.5- 7.75
10-60M320	60M320	12	60	150	450	12	7	15.0-15.5
5-81H120	81H120	6	81	200	600	16	7	7.5- 7.75
5-100M320	100M320	6	125	350	1000	25	7	7.5- 7.75
10-100M320	100M320	12	125	350	1000	25	7	15.0-15.5
5-150M320	150M320	6	171	450	1300	35	7	7.5- 7.75
10-150M320	150M320	12	171	450	1300	35	7	15.0-15.5
5-200M220	200M220	6	200	500	1500	40	7	7.5- 7.75
10-200M220	200M220	12	200	500	1500	40	7	15.0-15.5
5-280M220	280M220	6	280	700	2000	56	7	7.5- 7.75
10-280M220	280M220	12	280	700	2000	56	7	15.0-15.5
MILITARY VEHICULAR BATTERIES								
2HNC*	2HNC	12	35	30	300	8	7	15.0-15.5
6TNC*	6TNC	12	70	60	600	16	7	15.0-15.5

*The 2HNC and 6TNC batteries are approved under military specification No. MIL-B-26509.
NOTE: MIL-B-26509 now superseded by MIL-B-23272.

TABLE I (Continued)

SONOTONE FAA-APPROVED COMMERCIAL AIRCRAFT BATTERIES

Sonotone Type	Cell Type	Volts	CAPACITY A. H. 5-Hr. Rate	CAPACITY 20-Min. Amps.	CAPACITY 5-Min. Amps.	CHARGING Constant Current Amps.	CHARGING Constant Current Hours	CHARGING Constant Voltage Regulator Set
CA-4	24M220	24	25	65	200	5	7	28.0-29.0
CA-5	36M220	24	40	100	320	8	7	28.0-29.0
CA-6	24M220	24	25	65	200	5	7	28.0-29.0
CA-7	12M220	24	13.5	30	100	3	7	28.0-29.0
CA-9	24H120	24	24	75	225	5	7	28.0-29.0
CA-10N	10H120	24	13	35	120	3	7	28.0-29.0
CA-13	36H120	14	40	100	320	8	7	16.5-17.0
CA-15A / CA-15B	12M220	24*	15**	30	100	3	7	A=15.0-15.5 / A+B=28.0-29.0
CA-20	20M320	24	24	60	180	5	7	28.0-29.0
CA-20H	20H120	24	22	65	200	5	7	28.0-29.0
CA-21H	20H120	24	22	65	200	5	7	28.0-29.0
CA-24A / CA-24B	24M220	24*	25	65	200	5	7	A=15.0-15.5 / A+B=28.0-29.0
CA-31N	3H120	24	4	10	30	0.8	7	28.0-29.0
CA-40	40M320	24	44	110	350	9	7	28.0-29.0
CA-44A / CA-44B	40M320	24*	44	110	350	9	7	A=15.0-15.5 / A+B=28.0-29.0
CA-51N	5H120	24	6.5	15	50	1.5	7	28.0-29.0
CA-53N	5H120	24	6.5	15	50	1.5	7	28.0-29.0
CA-88A / CA-88B	60M320	24*	60	150	450	12	7	A=15.0-15.5 / A+B=28.0-29.0
CA-101N	10H120	24	13	35	120	3	7	28.0-29.0
CA-103	10H120	24	13	35	120	3	7	28.0-29.0
CA-121	12M220	27.5	13.5	30	100	3	7	33.0-34.5
CA-125	3H120	24	4	10	30	0.8	7	28.0-29.0
CA-727-3	24M220	24	25	65	200	5	7	28.0-29.0

*A and B together make up a 24-volt battery.
**At 8-hour rate.

SONOTONE MILITARY AIRCRAFT BATTERIES

Sonotone Type	Cell Type	Volts	MILITARY CAPACITY A. H. 2-Hr. Rate	Amps. 2 Hr.	Amps. 1 Hr.	Amps. 5 Min.	Amps. Peak Jet
MA-2	65M220	24	60	30	—	500	2000
MA-2-1	65H130	24	60	30	—	500	2000
MA-4	24M220	24	22	11	18.2	150	1000
MA-5	36H120	24	34	17	30	240	1500
MA-7	12M220	24	11	5.5	9.5	75	500
MA-8	24M220	24	22	11	18.2	150	1000
MA-9	24H120	24	22	11	18.2	150	1200
MA-11	24M220	24	22	11	18.2	150	1000
FMA-12	24M220	24	22	11	18.2	150	1000
MA-300H	3H120	24	3.6	1.8	3	30	100
MA-500H	5H120	26	5.7	2.9	5	50	175
MA-510H	5H120	24	5.7	2.9	5	50	175

MILITARY AIRCRAFT BATTERY CROSS-REFERENCE TABLE

Sonotone Type	U.S. Air Force Type MS—	U.S. Air Force Type MIL-B—	U.S. Army Type BB—	U.S. Army Type SCL—	U.S. Navy Type MS—	U.S. Navy Type MIL-B—
MA-2	MA-2	26026	—	—	90378-6	8565D
MA-2-1	MA-2-1	26026A	—	—	90378-7	8565D
MA-4	24497-1	26220B	434/A	6853	18045-45	8565D
MA-5	24498-1	26220C	433/A	6853	18045-46	8565D
MA-5	24498-2	26220C	—	—	18045-50	8565D
MA-7	24496-1	26220C	432/A	6853	18045-44	8565D
MA-7	24496-2	26220C	—	—	18045-48	8565D
MA-8	24497-4	26220C	—	—	—	—
MA-9	24497-5	26220C	—	—	90365-2	8565D
MA-11	—	—	—	—	90377-1	8565D
20-S102	—	—	—	—	17334-2	8565D

—a 40-ampere-hour battery may be permitted to discharge at 20 amperes.

IMPORTANT—Do not attempt to discharge a Sonotone sintered-plate, nickel-cadmium battery at an excessively high rate and then attempt to short circuit each cell at the end of this discharge. Batteries which have been discharged at high rates are not fully discharged. Application of shorting devices to the individual cells at the end of such a high discharge will produce severe arcing and intense heat. To determine when a battery has been sufficiently discharged and ready for short circuit, the terminal voltage of the entire battery must be less than 10% of the rated voltage. It is then safe to short circuit. *Example—a 12-volt battery having been discharged at a rate equal to or lower than the 2-hour rate may be short circuited when the terminal voltage of the entire battery is 1.2 volts or less (consult Description of Reconditioning Service, 9.4).*

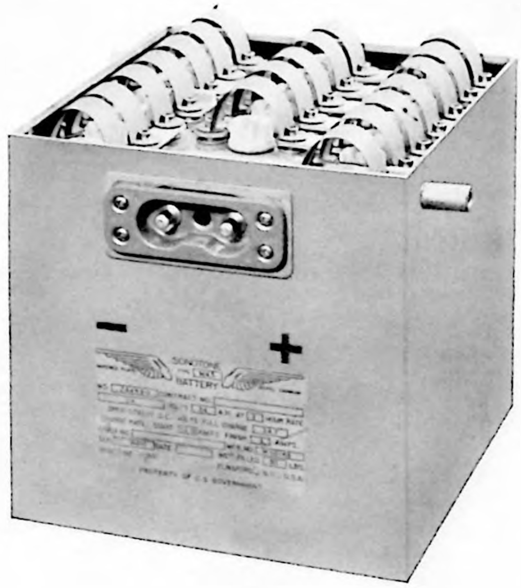


FIGURE 5

5.5 LIQUID LEVEL ADJUSTMENT

During the normal operation of the Sonotone sintered-plate, nickel-cadmium battery, it is necessary occasionally to add liquid. The amount of water used is relatively small when compared to the amount used in a lead acid battery. Usage rate will depend upon the application, charging voltage, ambient temperature and several other factors. For this reason, it is advisable to maintain accurate records on particular applications so a realistic water replacement schedule can be established. Use only distilled or demineralized water. Storage batteries are easily contaminated through the use of tap water which contains minerals, chlorines, softening agents and other foreign materials. Water additions to adjust the liquid level should be made immediately after charging or after the battery has been permitted to remain in a state of rest for a minimum of three hours. Never adjust the electrolyte level after discharge unless abnormal high voltage readings (greater than 1.5 volts) are encountered immediately after placing a discharged battery on charge.

WARNING: Do not use acid. Injury may result and equipment damage can occur. Never use tools which have any acid deposit on them.

5.5.1 PROPER LIQUID LEVEL

The proper liquid level of all Sonotone sintered-plate, nickel-cadmium batteries is just above the tops of the plates or plastic insert (1/4" immediately after charge or 1/8" after 3-hour stand). In some Sonotone batteries, it is possible to see the liquid level through the ports in the side of the battery can. In Sonotone batteries where these ports are not provided, such as certain aircraft types, it is necessary to determine this liquid level by looking down into the vent well after the filler cap has been removed.

If it is not possible to determine the liquid level in this manner, we recommend the use of a polystyrene tube, open on both ends and having approximately 1/8-inch inside diameter about six inches long *(see Figure 6)*.

This tube is inserted into the filler opening deep enough to touch the top of the plates or plastic insert. Grasping the tube between the thumb and the middle finger of the right hand, place the index finger over the top open end of the tube and remove the tube from the filler well. If the level in the lower

NOTE: Additional instructions on the liquid level adjustment when using Sonotone Battery BB-449/U—the proper electrolyte level is 5/8" above the tops of the plates measured from 3 to 6 hours after charge. An open end glass or preferably a transparent plastic tube 1/8" to 1/4" in diameter should be used for this, as described above.

end of the tube is as stated above, the liquid level is adjusted properly. If no liquid is withdrawn, add distilled or demineralized water until the proper level is reached in the polystyrene tube, using the method described above. Adjustments in liquid level may be made by a syringe of the type *pictured in Figure 7.*

5.6 ELECTROLYTE SPECIFIC GRAVITY

The electrolyte is a solution consisting of 70% distilled water and 30% potassium hydroxide, resulting in a specific gravity of 1.3. Cells which have lost electrolyte by accidental overfilling may have a lower specific gravity. Specific gravities after use may range between 1.240 and 1.320 without any appreciable effect on battery operation at normal ambient temperatures. We *do not* recommend that the user attempt to readjust this specific gravity unless it is extremely impractical to remove this battery from service long enough to have it properly adjusted at the factory. Should you find it necessary to make this adjustment, a supply of electrolyte may be purchased from your local Sonotone aircraft battery distributor or the Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523.

FIGURE 6

FIGURE 7

NOTE: Additional instructions on the electrolyte specific gravity when using Sonotone Battery BB-449/U—for low temperature operation at −40°F, the specific gravity should be 1.280 to 1.320.

6.0 Repair and Replacement

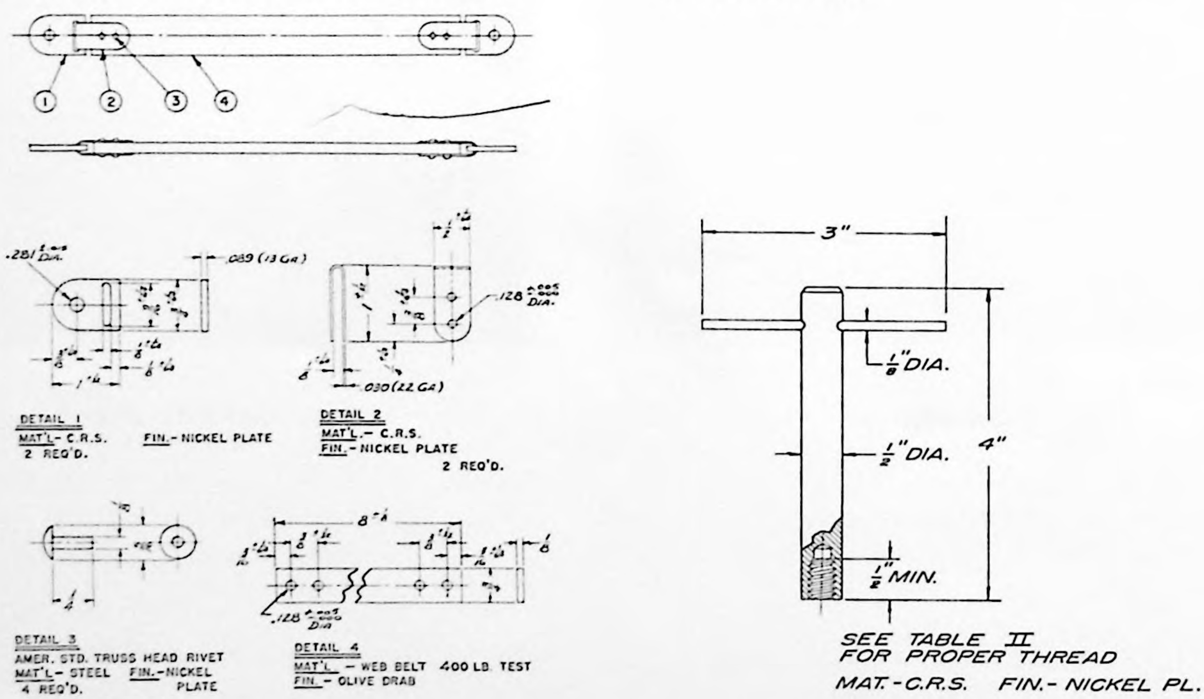
FIGURE 8

6.1 REPLACEMENT OF DAMAGED CELLS

If a cell becomes contaminated or physically damaged and the cell must be replaced, the procedure is as follows:

a. Clean battery *(consult General Care, 5.1).*
b. Remove end terminal connections. Save all the hardware.
c. Remove all vent plugs, using vent wrench *shown in Figure 8.*
d. Remove enough cell connections to permit the cell to be withdrawn from the battery case.
e. Do not withdraw cell from battery unless replacement cell is available immediately.
f. Withdraw cell, using one of the tools *shown in Figure 9. Also see Figure 10.*
g. Replace with new cell, making certain to insert the cell with the polarity symbols in the right direction. Cells are connected plus to minus. If the cell is difficult to insert, apply a light coat of petroleum jelly or silicone grease to the sides of the cell case before reassembly.
h. Replace connectors, assembling hardware finger tight. CAUTION: Do not use "homemade" hardware, as many of these parts are specifically designed to produce an adequate electrical connection. Spare or replacement hardware may be obtained from your local Sonotone Aircraft Battery Distributor or Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523.
i. Torque terminal connections to the values *indicated in Table II,* using calibrated torque

The tools shown in Figure 9 are not available from Sonotone. They are of simple construction and can be made in any machine shop.



CELL PULLER - CAP SCREW TYPE

CELL PULLER - HEX NUT TYPE

FIGURE 9

wrench. A typical torque wrench *is shown in Figure 11.*

j. Discharge entire battery *(consult Discharging a Battery, 5.4).* Monitor each cell to determine that all cells are completely discharged. Should some cells reverse and others retain a portion of their charge, it will be necessary to short the cells individually until each cell is completely at zero *(see Figure 5).*

k. Charge battery by constant current method *(consult Charging Methods, 5.3).*

l. Adjust liquid level *(consult Liquid Level Adjustment, 5.5).* The battery is then ready to be put into service.

m. Return damaged cells for analysis and possible repair to Customer Return Department, Battery Division, Sonotone Corporation, Cold Spring, N. Y. 10516.

6.2 REPLACEMENT OF DAMAGED END CONNECTORS

In some battery types, primarily those used in aircraft, the battery is provided with a special quick disconnect receptacle such as a type manufactured by Elcon or Cannon or any of a number of MS type receptacles. Should one of these connectors become damaged, it will be necessary to replace it with a replacement part obtained from your local Sonotone aircraft battery distributor or the Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523. Care should be taken in the removal of this connector to preserve all the hardware and gasketing, if possible, so that the new part may be installed properly.

To remove the connector, first remove those connections which go to the end cells in the battery, thus reducing the possibility of a short circuit when the connector body is removed from the battery case *(see Figure 12).* All Sonotone batteries have the same hardware arrangement, attaching the end connector to the battery, as is used on the intercell connectors. When installing the replacement part, it is necessary to *consult Table II* for torque values.

CAUTION: Do not substitute "home-made" hardware. Care must be taken that the polarity of the end connector is carefully observed so that, when the battery is installed in the equipment, the system will function properly.

6.3 MAINTENANCE RECORD KEEPING

In order to provide an accurate source of information on each battery in service, it is advisable to keep

(Continued on Page 17)

FIGURE 10

FIGURE 11

FIGURE 12

TABLE II

BATTERY OR CELL TYPE	THREAD SIZE	SOCKET HEAD CAP SCREW WRENCH SIZE	HEX NUT ACROSS FLATS	IN-LBS TO TIGHTEN
1H120,2H120	#6-32		1/4"	6-8
3H120,3L420 5H120,5L420	#10-32		5/16"	15-18
10L420, 10H120 12M220	#5/16-24		1/2"	20-25
12M220,10H120	#8-32	9/64"		30-35
20H120,20M320 36H120,36M320 24H120,24M220 24M320,40M320 60M320	#10-32	5/32"		35-50
100M320,150M320 200M220,280M220	#5/16-24	7/32"		180-200
MA-2	#1/4-28	3/16"		100-125
MA-4 MA-5 MA-8	#10-32	5/32"		35-50
MA-7	#5/16-24		1/2"	20-25
MA-300H MA-500H	#10-32		5/16"	15-18

a maintenance log on each. Should a battery malfunction, you will then be able to give the complete history of this specific unit to the Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523, and assist us in the determination of the problem. *A typical battery log is illustrated in Figure 13, inside back cover.*

Following is a list of typical malfunctions encountered in the maintenance and operation of sintered-plate, nickel-cadmium batteries. This list will serve as an index to the preceding information.

7.0 Trouble Shooting

7.1 APPARENT LOSS OF CAPACITY

A characteristic observed in nickel-cadmium batteries is apparent loss or temporary loss of capacity. When this temporary loss occurs, the battery capacity will be lower than the rated capacity. This effect is more common when recharging across a constant potential bus, such as in aircraft, than when recharging by the constant current method. The loss of capacity is normally an indication of imbalance between cells because of differences in temperature, charge efficiency, self discharge rate, etc., in the cells. In applications where lead acid batteries have been used, the serviceman is likely to treat this loss of capacity as a natural aging quality of the battery. Nickel-cadmium battery capacity does not decrease appreciably with age. A loss of capacity is a warning and should not be treated lightly. Periodic deep cycling will be an invaluable aid in alleviating this condition *(consult Reconditioning Service Procedures, 9.3).*

7.2 COMPLETE FAILURE TO OPERATE

Where a battery fails to operate at all, the trouble can usually be traced to an electrical connection. In some instances, the defective connection will be in the circuitry of the equipment in which the battery is installed. This would show up as a broken lead, a relay which fails to operate, improper plug or receptacle installation or similar difficulties. Failure in the battery itself can be caused by an end terminal connector becoming loose or disengaged or perhaps because the charge cycle failed to operate. Should the failure be due to poor intercell connection within the battery, clean and retighten hardware using the proper torque values *(consult Table II).*

7.3 EXCESSIVE SPEWAGE

A battery which has spewed excessively will usually display large crystalline deposits on the tops of the cells. In some cases, a considerable amount of liquid will collect in the bottom of the battery container. A battery in this condition has been subjected to high charge voltages or high ambient temperatures during charging or a combination of the two. The liquid level may also have been improperly adjusted. To correct this condition, clean the battery *(consult General Care, 5.1).* Then charge the battery as required and adjust the electrolyte level *(consult Liquid Level Adjustment, 5.5).* Place battery back into service.

7.4 DISTORTION OF CELL CASES

When a battery has one or more cells with distorted plastic cases, the battery may have been overcharged as described in *Excessive Spewage, 7.3.* This battery must be removed from service and either returned to the factory or sent into the maintenance shop for cell replacement *(consult Replacement of Damaged Cells, 6.1).*

7.5 FAILURE OF ONE OR MORE CELLS TO BALANCE WITH OTHERS

During the charging procedure *(consult Constant Voltage Charging, 5.3.4),* it is sometimes noted that one or more cells fail to rise to the required 1.50 to 1.55 volts at the end of charge. The battery should be treated *as described in Constant Current Charging, 5.3.1.* If these cells still fail to rise to the required voltage they should be removed and replaced according to the procedure *outlined in Replacement of Damaged Cells, 6.1.*

7.6 FOREIGN MATERIAL WITHIN THE CELL CASES

Cells which have been removed because of failure to respond to the normal charging procedures *see preceding paragraph,* may display some evidence of foreign substances within them. This material may be gray, black or brown in color. Such foreign substances are most commonly introduced into the cell through the addition of impure water or water contaminated with acid. Other causes for this dissolution

can be heat generated by extremely high rate charging, charging without sufficient electrolyte in the cell, too high a concentration of electrolyte or a combination of two or more of these conditions.

For instance, a battery has been serviced and electrolyte (potassium hydroxide) has been added to raise the specific gravity. The battery is then permitted to charge at a sufficiently high rate and drive off water. This produces a high concentration of electrolyte, which in turn generates some heat. This set of circumstances will damage the materials in the cell plates and will be indicated by the appearance of black or gray particles in the cell. These cells will usually show up as unbalanced *(consult Apparent Loss of Capacity, 7.1)* and must be removed from service.

7.7 FREQUENT ADDITION OF WATER

If one or more cells require more water than the others, they may be out of balance *(consult Apparent Loss of Capacity, 7.1)*. Discharged cells will always appear low in liquid *(consult Liquid Level Adjustment, 5.5)*.

7.8 CORROSION OF TOP HARDWARE

Excessive rust appearing on the top hardware of a battery may be caused by the presence of acid fumes in the area. This condition will be prevalent where batteries are installed in chemical plants or other places where they are subjected to corrosive fumes, spray or chemical moisture. The battery should be kept clean *(consult General Care, 5.1)* and installed in a compartment which has been cleaned *as per the instructions in Installation of Battery, 4.3.*

7.9 APPEARANCE OF BURN MARKS ON CONNECTORS

When an intercell connector or an end connector shows indication of burning, this usually denotes that the connectors involved have not been properly tightened. For proper torque values, *see Table II.* Burned outer connecting plugs is an indication of plug failure. The battery plug or the mating half should be replaced if necessary *(consult Replacement of Damaged End Connectors, 6.2)*.

7.10 OVERHEATING OF INTERCELL CONNECTORS

If intercell connectors become hot or show signs of overheating, disassemble, clean and reassemble. Torque the connections properly *as specified in Table II.*

7.11 BATTERY CASE LEAKAGE TO GROUND

When a battery has been in an aircraft for a considerable period of time, a voltage can sometimes be detected between either terminal pin or the metal battery case. This voltage is most usually caused by a collection of electrolyte around the cells, usually as a result of spewing from the cell vent caps. The electrolyte is conductive. It is for this reason that voltage can be read. Voltage is merely potential and of itself can do no harm.

The measure of whether or not this potential is affecting battery performance is the amount of current that this leakage path will support. If, for instance, the leakage path will support .050 amperes, this would be the equivalent of a battery self-discharging completely in 500 hours (CA-20 or CA-4). Usually, we consider .050 amperes or less a safe leakage path. Beyond that value, it is advisable to flush the battery vigorously with tap water and permit it to dry in the sun, if possible, or by applying forced warm air. When the battery is completely dried out, this leakage path should no longer be apparent.

The leakage may also be caused by a damaged case-to-cover seal on an individual cell. To determine which cell is damaged, the following method should be applied.

a. Place one probe of the voltmeter on either the positive or negative terminal post and the other against the battery case.

b. Observe the voltage.

c. Leaving the probe on the metal battery case, move the other probe from cell terminal to cell terminal.

d. The indicated voltage should decrease and finally go negative. At this changeover point, you will find the leaking cell.

e. This cell should be removed from service and returned for repair to the Customer Return Department, Battery Division, Sonotone Corporation, Cold Spring, N. Y. 10516.

f. Inspect surrounding cells and hardware for damage.

g. A new cell should be added *in accordance with Repair and Replacement, 6.0.*

7.12 HEATED BATTERIES

In some special applications, Sonotone has provided a specially designed battery which incorporates the use of an internal heater blanket and the

accompanying thermostats and input plug necessary to energize the heater. Batteries of this nature are composed of the same type of cells previously discussed in the various sections of this manual and, therefore, these difficulties encountered in cell performance can be handled exactly as though the battery were not equipped with a heater. The heater itself is usually an insulating blanket containing a wire filament. Failure of the blanket to operate can be caused by a break in this filament and is easily detected through the use of a continuity meter. Another cause of heater failure is sometimes centered in the operation of the thermostat. Thermostats can be checked by submitting them to sizeable temperature differences and checking their operation with a continuity meter.

Heater blankets and thermostats cannot be repaired in the field and, should a breakdown be experienced, the material must be returned for replacement to the Customer Return Department, Battery Division, Sonotone Corporation, Cold Spring, N. Y. 10516. Because of the large number of possible variations in heated battery design, it is not possible in this manual to become any more specific on this subject. In applications where heated batteries are used, if other troubles are encountered, contact Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523.

8.0 Storage

8.1 CHARGE RETENTION

Sonotone sintered-plate, nickel-cadmium batteries may be stored for long periods of time in any state of charge. The charge retention will depend largely on the ambient temperature of the storage area. A battery stored at 80°F will retain approximately 60% of its rated capacity over a period of one year. A battery stored in an ambient temperature of 0°F will retain approximately 90% of its capacity for a period of one year.

8.2 STORAGE MAINTENANCE

The active materials of the plates are insoluble in the electrolyte and therefore cannot react in any way with the electrolyte when the battery is stored on open circuit. Before placing a battery in storage, the battery should be cleaned *(consult General Care, 5.1)*. If long periods of storage are expected, it is advisable to coat the intercell connectors with a light coat of silicon grease to prevent any corrosion from forming. A battery being placed into service after storage should be given a freshening charge prior to installing it into the equipment *(consult Charging Methods, 5.3)*.

PART IV–SHOP PROCEDURE

9.0 Recommended Shop Procedure to Determine Condition of Aircraft Battery

The information in this part is a condensation of some of the procedures outlined in this manual, plus special information on aircraft batteries.

9.1 SEPARATION OF NICKEL-CADMIUM AND LEAD ACID BATTERY FACILITIES

Nickel-cadmium batteries use potassium hydroxide and distilled water as an electrolyte. Chemically, this electrolyte is an exact opposite of an acid electrolyte.

Anything associated with the lead acid battery (acid fumes included) should never come in contact with the nickel-cadmium battery or its electrolyte. Even traces of sulphuric acid from a lead acid battery entering the electrolyte of a nickel-cadmium battery will result in damage. Also, acid fumes can damage the hardware of the nickel-cadmium battery.

Separate shops are recommended for the two types of batteries. If separate shops are not possible, separate bench facilities shall be provided at opposite ends of the service area. Indicate each area clearly and keep all tools and materials separate and clearly marked.

9.2 VISUAL INSPECTION

A visual inspection of the battery in the aircraft should be made at least once every 50 flight hours on non-epoxy coated batteries and once every 100 hours on epoxy batteries. The battery connector, receptacle and vent lines should be checked for contact failure or damage and the allenhead screws or nuts should be torqued, *as per Table II.*

The cover should be removed to inspect for excess spewage and discoloration or deterioration of intercell hardware. Some slight deposits of potassium carbonates (white in color) may be encountered. If it is excessive, the battery should be removed and cleaned *(see below)*. Further inspection and replacement of parts is described in this manual.

9.3 RECONDITIONING SERVICE PROCEDURES

Flight hours are the main factor determining the frequency of reconditioning service procedure, depending on these four variables:

a. Type of starting service.

b. Duty cycle for battery.

c. Ambient operating temperatures.

d. Generator voltage regulator setting.

Therefore, we can only suggest an average time between reconditioning cycles *(Table III)* because of the widely varied flight profiles seen by individual aircraft. The user will eventually apply his experiences and the information gained during the reconditioning service in determining the maximum time. At no time should a battery be allowed to deteriorate to a point where the operation of the battery affects the mission or operation of the aircraft.

TABLE III

Aircraft Type	Approximate Flight Hours Between Reconditioning Cycles
Lear Jet Model 23	100
Jet Commander	100
Grumman Gulfstream I	500
Fairchild F-27	200
Boeing 727	400
Grand Commander	500
North American Sabreliner	200
Lockheed JetStar	150
Turbo Commander	200
MU-2	200

The use of a service log for each battery and aircraft is especially helpful to the user in determining the optimum period between reconditioning. A sample log and check list will be found on the inside back cover of this manual *(Figure 13)*.

9.4 DESCRIPTION OF RECONDITIONING SERVICE

The procedure for removing a battery for a reconditioning cycle should start with a visual inspection in the aircraft *(consult Visual Inspection, 9.2)*. If the battery needs cleaning, it can be performed in the maintenance area. If the spewage is minor, it can be removed with a nylon bristle brush and the battery flushed with water as follows:

9.4.1 FLUSHING OF BATTERY

a. Prior to flushing the battery with water, check the tightness of the vent plugs.

b. Tip battery on side away from battery receptacle.

c. The top of the cells should then be flushed with tap water.

d. Air hose away excess water.

NOTE: If any of the rubber insulation has deteriorated or pulled away from the can, the battery should be disassembled and the rubber recemented.

Use rubber-to-metal cement type 35-2 by G. C. Electronics or equivalent. Replacement can also be made by using neoprene rubber of a 40-60 dryrometer by Minor Rubber Company or equivalent. The rubber thickness is 1/16″ to 1/32″, depending upon the type of battery.

9.4.2 CHECKING CURRENT FLOW

After flushing and air hose drying, check the current flow between the positive terminal and the case, then the negative terminal and case.

a. First select a meter, such as Simpson 261 or 263, which contains an amperage scale of a minimum of 500 milliamperes. Select the highest current setting on the meter.

b. Take the positive lead of the meter and place on the positive terminal of the battery receptacle and the negative lead on the battery can.

c. Decrease the current setting until a scale is reached where, if any current flow exists, it is readable. Record the current.

d. Move the selector switch on the meter to the highest current setting. Place the negative lead of the meter on the negative terminal of the battery receptacle and the positive lead on the battery can. Proceed as outlined above.

e. If the current flow is more than 50 milliamperes, the unit should be disassembled and cleaned.

NOTE: Do not use the voltage reading between the terminals and the battery can as a criteria for rejection, since current flow is the determining factor.

9.4.3 EPOXY-COATED BATTERIES

Some Sonotone nickel-cadmium batteries are now supplied with the battery container and cover epoxy-coated. In this instance, the current flow may be measured by reading from the battery terminals of the receptacle to the snaps that restrain the cover. This is mainly a safety precaution, since in epoxy-coated cans the cells should be completely insulated from the battery case.

9.4.4 CHARGING

The battery should then be charged on a charger/analyzer *(Sonotone Model PCA-131—see later reference)* on a constant current source at a 5-hour charge rate or on a constant potential source at 28.5 volts for a 24-volt battery. *(For aircraft batteries of other voltages, use 1.5 volts by the number of cells = constant potential charge volts.)* If the constant current charge is used, continue until the total battery voltage reaches 30 volts *(average 1.58 volts/cell)*.

9.4.5 USING CONSTANT POTENTIAL

If a constant potential charge is used, continue charge only until the current tapers off and stabilizes.

9.4.6 ADJUSTING ELECTROLYTE

At this time the electrolyte level may be adjusted to ¼" above the top of the plates or visible insert. If the battery is allowed to stand 2 to 4 hours after charge, then the level should be adjusted to ⅛" above the plates or visible insert.

NOTE: Make adjustments with distilled, deionized or demineralized water. We do not recommend the addition of potassium hydroxide, as water only is normally lost due to electrolysis. Potassium hydroxide can be added only on specific instructions from the Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523.

9.4.7 DETERMINING STATE OF CHARGE

Unlike a lead acid battery, the electrolyte in a nickel-cadmium battery acts only as a conductor. Therefore, it is impossible to determine the state of charge from the specific gravity or from open circuit voltage readings. The only way to tell the state of charge is by a measured discharge.

9.4.8 DISCHARGE

At this time, the battery is ready for discharge. Select a discharge rate of either the 1 or 2-hour rate *(see Table IV)*.

a The total battery voltage should be monitored until an average of 1.0 volt/cell is reached.

b. At this point, the time should be recorded.

c. If the discharge time is less than 70% of that specified *(see Table IV)*, then a supplemental discharge (deep cycle) should be performed.

TABLE IV

Battery Type	*Rate 1-Hour*	*Rate 2-Hour*	*Battery Type*	*Rate 1-Hour*	*Rate 2-Hour*
CA-4	20	11	CA-40	38	20
CA-5	34	17	CA-44	38	20
CA-6	20	11	CA-51	5.0	2.5
CA-7	10	5.5	CA-52	5.0	2.5
CA-9	20	11	CA-53	5.0	2.5
CA-10	10	5.0	CA-88	55	30
CA-15	10	5.5	CA-101	10	5.0
CA-20	20	11	CA-102	10	5.0
CA-20H	20	11	CA-121	10	5.5
CA-21	20	11	CA-727	20	11
CA-24	20	11			
CA-31	3.0	1.5			

Cutoff voltage of 1.0 volt/cell.

9.4.9 DEEP CYCLING

The deep cycle consists of continuing the discharge listed above.

a. As each individual cell reaches 0.6 volt, a metal shorting strap should be placed across the terminals while the load is still applied. It will be impossible to short out all cells within a battery since, during constant resistance discharge, the current decreases as the voltage decreases. Therefore, when approximately 75% of the cells are shorted with metal straps, a 1.0 ohm resistor of 1 or 2 watts should be placed across each of the remaining cells.

b. The battery should remain shorted as above for a period of 3 or more hours.

c. If the discharge time is 70% or greater than that specified *(see Table II)*, the supplemental discharge (deep cycle) can be eliminated.

TABLE V

Battery Type	Time	Current	Battery Type	Time	Current
CA-4	7-hour	5-amp	CA-40	7-hour	8-amp
CA-5	"	8-amp	CA-44	"	8-amp
CA-6	"	5-amp	CA-51	"	1.0-amp
CA-7	"	3-amp	CA-52	"	1.0-amp
CA-9	"	5-amp	CA-53	"	1.0-amp
CA-10	"	3-amp	CA-88	"	12-amp
CA-15	"	3-amp	CA-101	"	3-amp
CA-20	"	5-amp	CA-102	"	3-amp
CA-20H	"	5-amp	CA-121	"	3-amp
CA-21	"	5-amp	CA-727-3	"	5-amp
CA-24	"	5-amp			
CA-31	"	0.8-amp			

9.4.10 FINAL CHARGE

The battery is now ready for charge. Charge battery by the constant current method only.

a. Place the battery on charge at the 5-hour rate for 7 hours *(Table V)*. Care should be taken to see that the total ampere-hour charge equals that outlined in Table V. If the charge current decreases during charge, manually adjust current to maintain the proper value.

b. During the final 5 minutes of charge (for automatic chargers that have terminated, reset the charge for 10 additional minutes), the voltage of each individual cell should be read.

c. The minimum voltage should be 1.55 volts/cell and the maximum 1.75 volts/cell at room temperature (70-80°F). If any cell fails to rise to at least 1.55 volts, the constant current charge should be continued for an additional hour. At this time, monitor the cell voltage again.

d. Any cell that fails to rise above 1.55 volts or exceeds 1.75 volts should be removed from service and may be returned for rebuilding or overhaul to Customer Return Department, Battery Division, Sonotone Corporation, Cold Spring, N. Y. 10516.

NOTE: Any battery having a discharge time less than 70% of that specified in Table IV SHOULD be given another discharge and recharge *(per Discharge, 9.4.8, and Deep Cycling, 9.4.10)*.

CAUTION: Any battery having a discharge time less than 30% of that specified in Table IV MUST be given another discharge and recharge *(per Discharge, 9.4.8, and Deep Cycling, 9.4.10)*.

9.4.11 COMPLETION OF CHARGE

Following completion of the charge, the electrolyte level should again be checked, using the levels outlined earlier *(consult Adjusting Electrolyte, 9.4.6)*. Torque the nuts or allenhead screws, attached to the intercell connectors *(see Table II for correct torque values)*.

9.4.12 CHECKING CURRENT PATH

The final step now is to recheck the current path between the cell and battery case, using the maximum current outlined previously *(consult Checking Current Flow, 9.4.2)*.

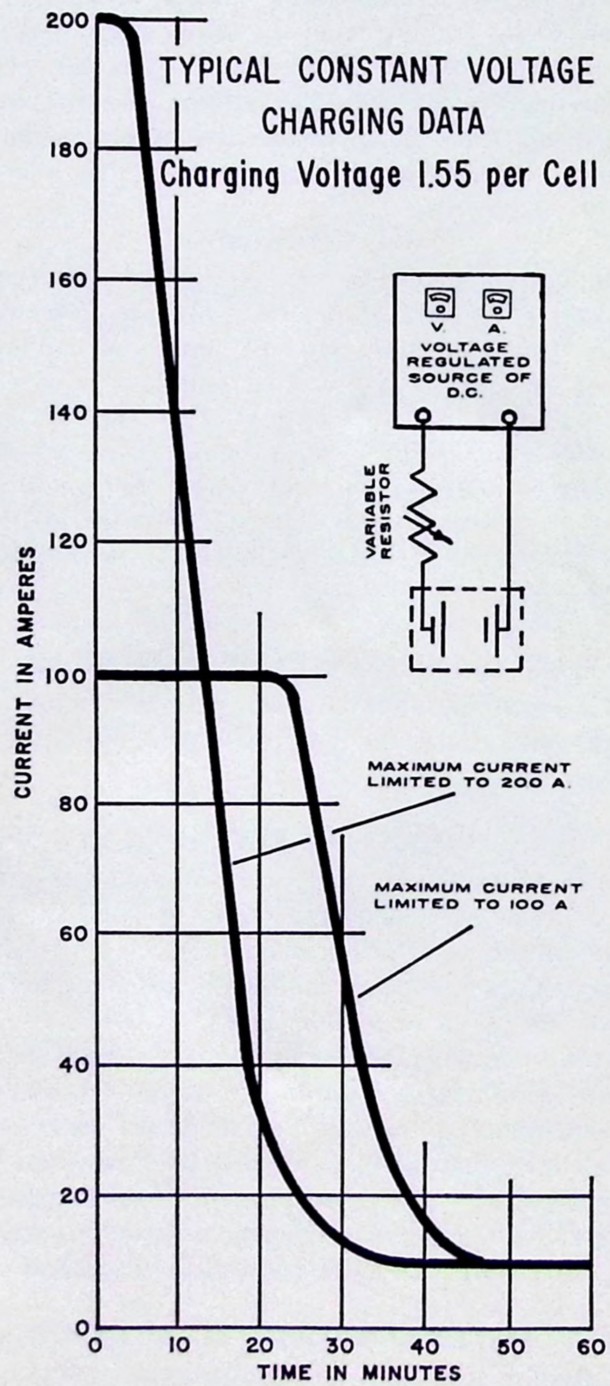


FIGURE 4

10.0 Sonotone Battery Charger/Analyzer PCA-131

10.1 IMPORTANCE OF RECONDITIONING

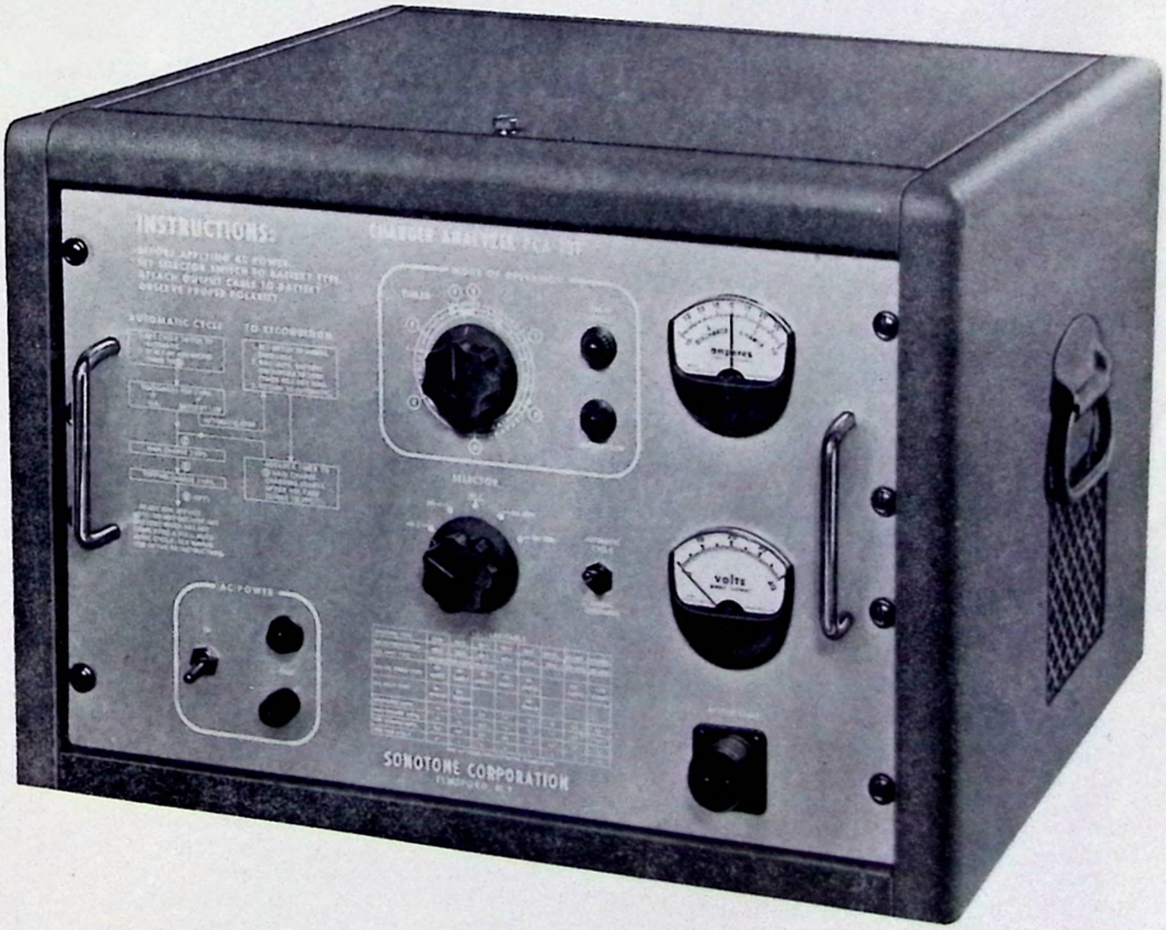
The data obtained in performing the reconditioning cycle is invaluable for determining the maximum flight hours between reconditioning service. More frequent reconditioning is recommended whenever possible, however.

In aircraft where more than one battery is used, either in series or parallel starting, care should be taken that the batteries are not allowed to become unbalanced. Perform the reconditioning service on both batteries during the same inspection period.

The Sonotone Model PCA-131 Charger/Analyzer is designed to provide maximum service from nickel-cadmium aircraft batteries. It features a "Go, No-Go" indication of battery condition.

The correct charge and discharge current is preselected with the setting of the switch position. The battery can be left unattended during charge and automatically adjusts for changes in line voltage. It will automatically terminate the discharge if the average battery voltage falls below a preselected end voltage. You can then determine the actual discharge time from the running timer. The discharge percentages discussed also apply to the Sonotone Charger/Analyzer.

Complete information on Sonotone's solid state Charger/Analyzer, the Model PCA-131—such as operation instructions and charger/analyzer specifications—may be obtained from the Field Service Manager, Battery Division, Sonotone Corporation, Elmsford, N. Y. 10523 *(request Data Sheet BA-166)*.



The Sonotone PCA-131 Battery Charger/Analyzer

CROSS REFERENCE AND REPLACEMENT DATA ON SONOTONE NICKEL-CADMIUM AIRCRAFT BATTERIES

These listings indicate the Sonotone battery types used as original equipment, retrofitted and recommended replacement types for corporate, business, private, commercial and helicopter aircraft. To use, simply locate the aircraft and model you are now flying. The Sonotone battery or recommended replacement then appears in the extreme right hand column.

BUSINESS and PRIVATE AIRCRAFT
Single Engine

Aircraft Manufacturer	*Aircraft Model*	*Sonotone Battery Type*
Beech	Bonanza S35	CA-24
	Debonair C33	CA-24
	Musketeer A23	CA-24
Cessna	Commuter 150	CA-15 or CA-24
	Skyhawk 172	CA-15 or CA-24
	Skylark 175	CA-15 or CA-24
	Skylane 180-182	CA-24
	Skywagon 185	CA-24
	Super Skywagon 205	CA-24
	Centurion 210	CA-24
Helio	Courier	CA-7*
	Stallion	CA-20H*
Lake	LA-4 Amphibian	CA-4
Mooney	Mark 21	CA-4
	Super 21	CA-4
	Mark 22 Mustang	CA-4
Navion	Mark 21	CA-24A & B
Pilatus	Porter	CA-5
Piper	PA-18 Cub	CA-15
	PA-28 Cherokee	CA-15
	PA-32 Cheyenne	CA-15 or CA-24
	PA-24 Commanche	CA-24
	Colt	CA-15 or CA-24
	Papoose	CA-15 or CA-24

COMMERCIAL
Helicopters

Aircraft Manufacturer	*Aircraft Model*	*Sonotone Battery Type*
Bell	Jet Ranger	CA-103N*
Bell	47 G / J	CA-7*
Boeing-Vertol	107, 114	CA-5*
Brantly	B-2B, 305	CA-7
Hiller	12-E	CA-10H*
	FH-1100	CA-102
Lockheed	286	CA-104N*
Sikorsky	S-55, 58	CA-5*
	S-61L	CA-11*
	S-62	CA-11*
Sud	Allouette	CA-5

BUSINESS and PRIVATE AIRCRAFT
Twin Engine

Aircraft Manufacturer	*Aircraft Model*	*Sonotone Battery Type*
Aero Commander	Grand Commander	CA-4*
	680F	CA-4*
	560F	CA-4*
	500V / B	CA-4*
Beech	Baron B55	CA-24A & B or CA-7
	Queen Air 65	CA-7
	Queen Air A80	CA-7
	Super H18	CA-24A & B or CA-7
	Travel Air D95A	CA-15A & B, CA-24A & B or CA-7
	Twin Bonanza	CA-15A & B, CA-24A & B or CA-7
Cessna	Skynight 320	CA-15A & B, CA-24A & B
	Skymaster	CA-15A & B, CA-24A & B
	310	CA-15A & B, CA-24A & B
	411	CA-4
Piper	Twin Commanche	CA-4 or CA-7
	Apache	CA-4 or CA-7
	Aztec C	CA-4 or CA-7
	PA-31	CA-7
Swearingen	Merlin 1	CA-7, CA-4, CA-24A & B

***Supplied as original equipment.**

CORPORATE and BUSINESS AIRCRAFT
Turbojet and Turboprop Types

Aircraft Manufacturer	*Aircraft Model*	*Sonotone Battery Type*
Aero Commander	Jet Commander	CA-4*
Aero Commander	Turbo Commander	CA-9*
Beech	King Air	CA-5
Dassault	Mystere 20	CA-5
Douglas	DC-9	CA-13
DeHavilland	DH-125	CA-9 or CA-125
Fairchild-Hiller	F-27 Friendship	CA-20H or CA-5*
Fairchild-Hiller	F-227 Friendship	CA-20H*
Fairchild-Hiller	Turbo Porter	CA-5*
Grumman	Gulfstream I	CA-5*
Grumman	Gulfstream II	CA-5*
Hansa	HFB-320	CA-9*
Lear	Learjet	CA-21H*
Lockheed	JetStar	CA-5*
Mooney-Mitsubishi	MU-2	CA-21H and CA-31H*
Nihon	YS-11	CA-5*
North American	Sabreliner	CA-5 or CA-9*
Piaggio-Douglas	Vespajet	CA-9
Potez	840	CA-5
Swearingen	Merlin 2	CA-5*
Swearingen	Merlin 2A	CA-9*

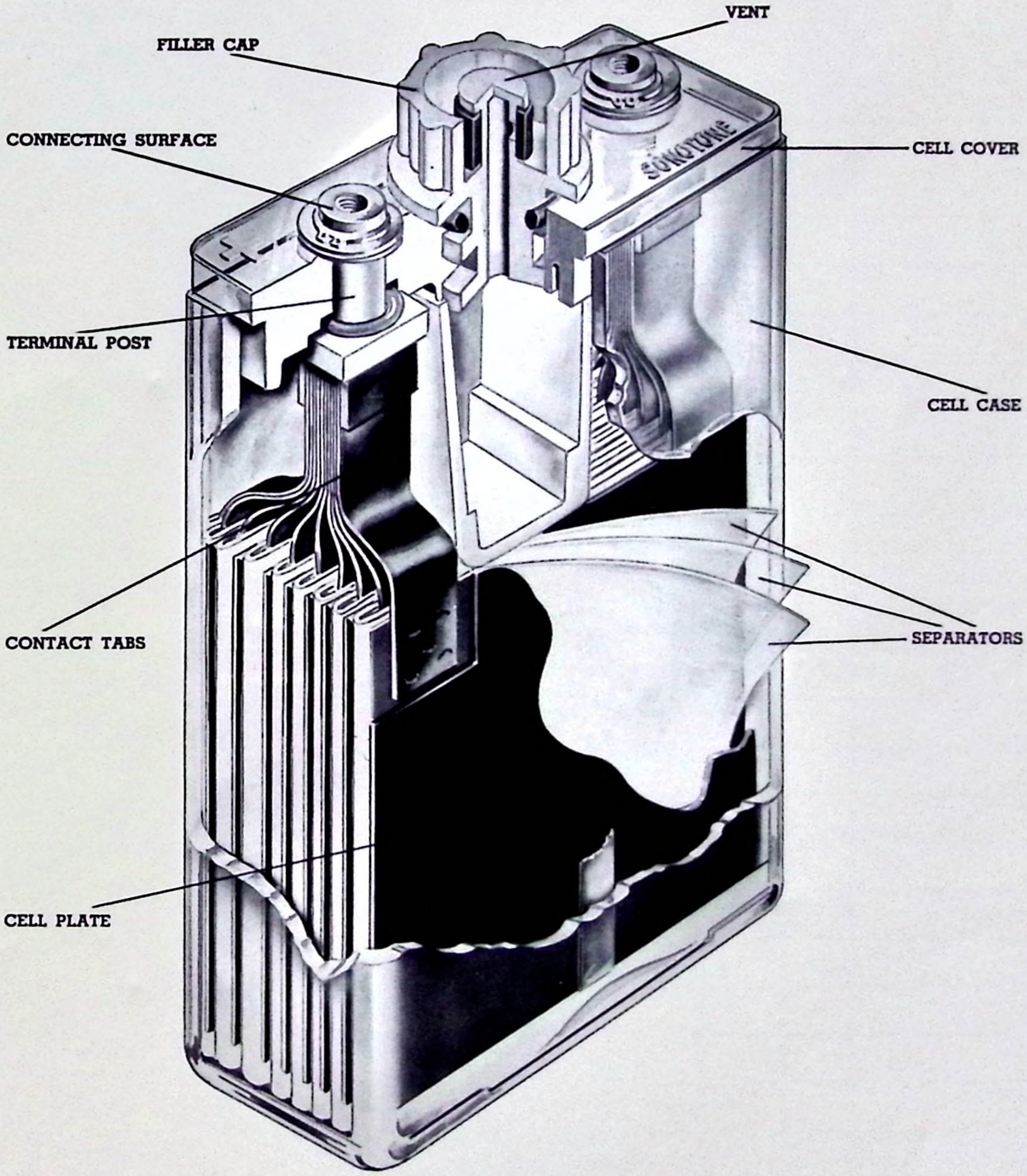
COMMERCIAL AIRLINE
Transports

Aircraft Manufacturer	*Aircraft Model*	*Sonotone Battery Type*
British Aircraft Corporation	BAC-111	CA-20H
BAC-Vickers	VC-10	CA-4
Bristol	Brittania	CA-5
Boeing	707 / 720	CA-4, CA-31H (Pan Am)* CA-53N (Pan Am)*
Boeing	727	CA-727-3*
Boeing	737	CA-727-3*
Douglas	DC-3 thru DC-7	CA-88A & B or CA-44A & B
Douglas	DC-8	CA-51N,* CA-53N (Pan Am)*
	DC-8 Eastern Airlines	CA-101N*
Douglas	DC-9	CA-13
DeHavilland	Comet IV	CA-4
Fairchild	F-27 Friendship	CA-20H*
Fokker	F-27 Friendship	CA-5 or CA-20H*
Fokker	F-28	CA-9*
General Dynamics	CV240, 340, 440	CA-88A & B or CA-44A & B
General Dynamics	Dart 600	CA-14
General Dynamics	CV880, CV990	CA-121*
Handley Page	Dart Herald	CA-4
Hawker Siddeley	Trident	CA-4
Lockheed	Constellation 749 thru 1649	CA-5
Lockheed	Electra II	CA-4
Martin	202, 404	CA-40
Vickers	Viscount	CA-20
Vickers	Vanguard	CA-12

COMMERCIAL AIRLINE
Cargo

Aircraft Manufacturer	*Aircraft Model*	*Sonotone Battery Type*
Boeing	707-320C	CA-4
Boeing	727C	CA-727-3*
Canadair	CL-44 Yukon	CA-4
Curtis Wright	C-46 Commando	CA-5
Douglas	DC-8F Trader	CA-51H*
Hawker Siddeley	Argosy	CA-4
Lockheed	Constellation	CA-5

CUTAWAY VIEW
OF TYPICAL SONOTONE
NICKEL-CADMIUM
VENTED CELL



NOTES

FIGURE 13

SONOTONE CORPORATION

BATTERY LOG
&
CHECK LIST

BATTERY TYPE ______________ S/N ______________ DATE INSTALLED ______________________

CHECK THESE ITEMS

DATE	CONDITION OF OUTER CASE OR COVER	CONDITION OF OUTPUT CONNECTOR	CLEANLINESS OF CELLS AND HARDWARE	CONDITION OF FILLER CAPS	TIGHTNESS OF INTERCELL CON-NECTOR HARDWARE	TIGHTNESS OF END CONNECTOR HARDWARE	AVERAGE SPEC. GRAVITY	ELECTROLYTE LEVEL	CELL VOLTAGE AT END OF CHARGE	HOT SPOTS	REMARKS WATER ADDITION CELL REPLACEMENT ETC.

Sonotone Batteries®

portable power for progress

BATTERY DIVISION, SONOTONE CORPORATION, ELMSFORD, NEW YORK 10523